WATER RELATIONS IN SEED BIOLOGY

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ABSTRACT: The water relations play a fundamental role in seed biology. Thus, the purpose of the present paper was to analyze the performance of water status in seed development and germination. The researches have suggested that the water potential of the seed or seed structures provides a better indicator of the seed water status than water content. The seed water status plays a regulatory role in seed development and germination.
Key Words: water status, hydration levels, water potential

RELAÇÕES HÍDRICAS NA BIOLOGIA DA SEMENTE

RESUMO: As relações hídricas exercem um importante papel na biologia da semente. Desta forma, o presente trabalho objetivou apresentar uma análise do comportamento do estado da água no desenvolvimento e na germinação da semente. As pesquisas mostram que o potencial hídrico da semente ou de suas estruturas pode constituir-se num indicador mais eficiente do estado da água do que o teor de água e que este estado apresenta um papel regulador no desenvolvimento e na germinação de sementes.
Descritores: estado da água, tipos de água, potencial hídrico

INTRODUCTION

The water relations play a fundamental role in the comprehension of seed biology, particularly in development and germination processes.

For orthodox species the desiccation period is a normal event in embryo development leading to a quiescent metabolism status that is placed between development and germination. The desiccation, however, is not a prerequisite for the beginning of the germination and growth processes since the embryo may become capable of performing its role in germination before the end of the seed development. On the other hand, in recalcitrant species seeds may go from the development to germinative stage without the quiescence period (Kermode, 1995).

Recent researches have pointed how gene expression programs, synthesis and perception to abscisic acid and seed water status are intricately interwoven in determining the course of seed development and germination.

The sequence of changes in seed water content has become a relatively efficient parameter in the characterization of the seed development and is often employed in the determination of the physiological maturity. Nonetheless, this has been proved inadequate to indicate the physiological water status during seed development once it fails to provide information on the availability of water or its energy status.

In view of the significance of the water relations in seed biology the target of this paper is to present an analysis of the behavior of water status on seed development and germination.

THE WATER POTENTIAL AND HYDRATION LEVELS

The seed water may be characterized by an energy status and is likely to be determined through the potential energy. Such energy status is conveniently described by the total water potential which, in the form of energy per volume unit, can be expressed in pressure measurement units (Villela et al., 1991)

The Second Law of Thermodynamics establishes that a water system can only spontaneously evolve to a status in which the decrease of Gibbs' free energy occurs. Thus, the total water potential allows the verification of whether a system is or is not water-balanced as well as to predict the orientation of the spontaneous water flow towards potential water decrease (Labouriau, 1983; Salisbury & Ross, 1992).

An overall approach of the phenomena comprising soil, seed, and atmosphere water demands that according to the superposition principle, the measurement of the water potential has to be an additive function of several terms, each one representing one type of interaction among water molecules and other constituents. This way, the seed water potential can be expressed by the sum of osmotic, matric and pressure potentials.

In normal atmospheric pressure environments the osmotic potential of water in the seed is always negative in view of the solutes as well as the matric potential, because of the colloids found in seed cells. As a consequence, the total water potential of the seed and seed structures is always negative.

The superficial properties of the macromolecules, particularly the proteins for their physiological attribute, are modified by the water level (Labouriau, 1983). Discrete changes in the metabolic activity of seeds according to the water content are likely to be associated to discrete changes in the physical properties of water (Vertucci & Farrant, 1995).

Considering the multiple macromolecule water sorption sites model, Vertucci (1993) and Vertucci & Farrant (1995) describe five types of seed water and corresponding potential interval and water content according to the molecule mobility and phase properties (TABLE 1).

The water removal from a cell increases the concentration of solutes and therefore causes an eventual flow decrease of the fluidity of the aqueous medium thus affecting the cell metabolic status. Hence, several studies have suggested the association between critical water content levels and discrete changes in the metabolic activity.

TABLE 1 - Water types, water potentials and water contents in seeds (Adapted from Vertucci, 1993 and Vertucci & Farrant, 1995).

Water Type	Water Potential (M Pa)	Water content (%) dwb[1]	fwb[2]
Type 1	< - 150	< 8.0	< 7.5
Type 2	- 150 to - 11	8.0 - 25	7.5 – 20
Type 3	- 11 to - 4	25 - 45	20 – 33
Type 4	- 4 to - 1.5	45 - 70	33 – 41
Type 5	> - 1.5	> 70	> 41

[1] dwb is water content on a dry weight basis
[2] fwb is water content on a fresh weight basis

SEED WATER STATUS DURING SEED DEVELOPMENT AND GERMINATION

The seed water content after fertilization is typically high and decreases as seed development occurs until the physiological maturity. The duration of the development phase and respective decrease in water content depends on the species, cultivar, current environment, and plant development stage. After the physiological maturity, the decline of the seed water content goes on, often in a more accelerated way, until it begins to oscillate according to the relative air humidity when the harvest is not performed in advance.

The hydration of mature, dry, and nondormant seeds establishes the beginning of the germination process when the seed is in a favorable environment, with the reactivation of the metabolic system and synthesis of new compounds (Labouriau, 1983). This fact emphasizes that the desiccation exerts influence on the redirection of the cell metabolism, from the development program to the germination and growth program (Kermode, 1995). The seed water content in the recovering of the embryo growth varies more evidently among species, as seen on TABLE 2 for maize, soybeans and wheat. However, the values found are verified to be similar to those of the physiological maturity.

One must emphasize that along the imbibition process the embryo/embryonic axis absorbs water at a speed higher than that of the reserve tissue. Thus, different seed structures may vary as to water content. Under a given environment, seeds with prevailing cotyledonal reserves have a higher water content in the embryonic axis in relation to the cotyledon and the endosperm ones, higher in the embryo than in the endosperm, as shown in TABLE 3, in soybean and maize seeds.

TABLE 2 - Seed water status at physiological maturity and the germination (radicle protrusion) for maize, soybean and wheat. (Adapted from Egli & TeKrony,

Species	Physiological Maturity		Germination	
	Water Content[1] (%)	Water Potential[2] (M Pa)	Water Content[1] (%)	Water Potential[2] (M Pa)
Maize	37.7	- 1.61	33.2	- 2.20
Soybean	59.0	- 1.52	51.4	- 2.07
Wheat	43.7	- 1.66	34.5	- 2.20

[1] Water Content of whole seeds on a fresh weight basis
[2] Water potential of embryo (maize and wheat) or embryonic axis (soybean)

TABLE 3 - Water content of maize seed structures (embryo, endosperm, and whole seed) and soybean seed structures (embryonic axes, cotyledons, and whole seeds) in germination (radicle protrusion). (Adapted from McDonald et al. 1988, 1994).

Seed Structures	Water Content (%)[1] Soybean	Maize
Embryonic axes/embryo	70-80	50-55
Cotyledon/endosperm	55-60	25-30
Whole seed	60-65	30-35

[1] fwb is water content on a fresh weight basis.

The water potential of the embryo/ embryonic axis remains relatively constant along a great deal of the seed filling period, decreases rapidly with the approach of the physiological maturity and then continues to decline according to the environment and physical barriers to the seed water movement to the surrounding air (Saab & Obendarf, 1989; Westgate, 1994; Egli & Tekrony, 1997).

During imbibition, the water potential - low at first - rapidly increases as the seed water content raises and reaches a certain level in early germination (radicle protrusion). In addition, it shows slight differences in water potential in the embryo/embryonic axis among species (Egli & Teknony, 1997).

The similar water potential of the embryo and embryonic axis among species at the physiological maturity and early germination, as shown in Table 2, suggests that the water status can play a regulator role in seed development and germination, according to Bradford (1994), Kermode (1995) and Egli & Tekrony (1997).

CONCLUSIONS

The researches have shown that the water potential of seeds or seed structures can constitute a more efficient indicator of water status than water content and that this status plays a regulator role in seed development and germination.

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